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AN ABSOLUTE ∫Bdl CALIBRATION OF B2 MAGNETS FOR THE AVB SYSTEM OF THE SINGLE ARM SPECTROMETER FACILITY

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The change of scattering angle for the Single Arm Spectrometer (SAS) in the M6 beam line is done by magnetically deflecting the incident beam so that it passes at an angle through the H_2 target. This is done by three Angle Varying Bends (AVB). (Figure 1) AVB1 is stationary, AVB2 can be moved remotely up and down, and AVB3 has a combined up down and tilting movement to follow the deflected beam. AVB2 and AVB3 have the same palority and are opposite to AVB1. The ∫Bdl of the system is proportional to the scattering angle and must be known with good precision.

The most important data are summarized in Table 1. In order to get an absolute calibration of ∫Bdl which relates to an easily monitored quantity in a reproducible way, we use a 3' Reference Magnet (AVBRef) in series as our standard. Before any measurement the magnets and AVBRef get degaussed to get them tracking. Above 12KG(-3000A) mainly AVBRef goes differently into saturation and tracking is lost. Our calibrations are only valid for B≤ 12KG This was verified to about 5 Gauss using a Rawson-Lush rotating coil put about 2' from one end into a magnet. The data are shown in Figure 2. Points beyond 12KG and coming back down from there clearly deviate.

To get the absolute calibration two different methods were tried. The magnet was measured on the test stand of the Fermilab magnet measurement group using their long flip coil. The integrator time constant was measured in three different ways agreeing and repeating perfectly. Also the integrated output voltage measurement was completely reliable. But the coil itself proved non-reproducible for the 10' magnets to better than 1%.

This two turn stretched wire coil was designed for measuring the 20' magnets. No definite cause could be found in the finite amount of time available. Therefore we resorted to map the field in the homogenous part every 2" using an NMR probe. The end fields were mapped with a Rawson-Lush rotating coil, taking measurements every 2cm. For the NMR measurement it was essential to put the probe into a 6"x1.75"x3.5"Cu bloc to cancel the power supply ripple by eddy currents. For ABV2 about 1/3 of the magnet stays unmapped due to the length of the probe cable. The measurements are displayed in Figure 3-8. Inside the homogeneous part field variations of ±.1% are found, which result from random variations of the stacking of laminations. The ratio of the average field to the reference field is given in Table 1.

The mapping of the end fields was numerically integrated and expressed as $\Delta l = l_{mag} - l_{steel}$. Since the variations from one magnet to the next, most likely coming from small positioning erros, do not show as systematic differences on the plots of the end field, only one average value for each with and without mirror plate was finally used. Results are given in Table 1.

PREDICTIONS OF BEAM EXCURSION

The attached Fortran program was used to compute the various beam excursions, necessary field values in AVBRef and the height of a hodoscope in between AVB2 and AVB3 for various scattering angle θ and beam momenta.

There is a small residual steering effect (DYTGT) left at the center of the target, where the beam should cross the nominal beam line. This can be suppressed by using a shunt bypassing around AVB2 and AVB3 a fraction DII of the current. Results are given separately for DII=0 and DII≠0.

The approximation used to predict the current is good to about 1%. The field prediction is the primary number. Results of this calculation are given in Table 2 and 3. One should note that the beam steering is not only sensitive to the magnet calibration but also their placement.

We would like to thank the staff of the Fermilab magnet measurement group for their help with equipment and measurements.

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C     THIS PROGRAM IS ONLY TO PRINT A NICE TABLE
       IOUT=7
       DO  20  JP=50,200,50
        P=FLOAT(JP)
        WRITE (IOUT,101) P
  101    FORMAT (1H1,F10.1,6H GEV/C  /
     1   70H0THETA   B/TH   I/TH   DI/I  H2/TH  H3/TH HHO/TH AL3/TH AHO/T
     2H  DYTGT   /
     3   70H     MR   G/MR   A/MR     %  MIL/MR MIL/MR MIL/MR
     4      MIL     )
        DO 10 I=1,40
        THETA=FLOAT(I-7)*4./1000.
        IF (THETA.EQ.0.) GOTO 10
        CALL AVB(THETA,P,BREF,CAVB,DCAVB,HAVB2,HAVB3,HHOD,ALF3,THHOD,Z)
        DCAVB=100.*DCAVB/CAVB
        IF (ABS(BREF).GT.18.) GOTO 10
        BREF=BREF/THETA
        CAVB=CAVB/THETA
        CAVB=CAVB/1000.
        HAVB2=HAVB2/THETA
        HAVB3=HAVB3/THETA
        HHOD=HHOD/THETA
        ALF3=ALF3/THETA
        THHOD=THHOD/THETA
        THETA=THETA*1000.
        WRITE (IOUT,100) THETA,BREF,CAVB,DCAVB,
     1                     HAVB2,HAVB3,HHOD,
     2                     ALF3,THHOD,Z
  100   FORMAT (1H0,F5.1,F7.2,F7.2,F7.3,3F7.2,2F7.4,F7.1)
   10   CONTINUE
  20   CONTINUE
        END
        SUBROUTINE AVB(THETA,P,BREF,CAVB,DCAVB,HAVB2,HAVB3,HHOD,
     1               ALF3,THHOD,ZERO)
        REAL AL(3),POS(4),L(4),DLL(3),BL(3)
        DATA AL/120.41,238.64,119.42/,
     1       POS/1410.974,1443.849,1462.578,1455.691/,
     2       POSTGT/1469.858/,BEAMTH/0.006/
        DATA  ICALL/0/
        IF (ICALL.NE.0)  GOTO 100
        ICALL = 1
C       HODO IS 4.3 IN DWN OF POS(4)=CENTER OF GAP
        POS(4)=POS(4)+4.3/12.
        DO 10 I=1,4
   10   L(I)=-(POS(I)-POSTGT)*12./COS(BEAMTH)
C
  100   CONTINUE
C     TOTAL NEEDED BENDPOWER IN KGAUSS*INCH
        SIBDL=P*THETA/0.00915
        SIBDL=SIBDL*12.
C       CORRECT FOR ACTUAL LENGTH IN MAGNET DUE TO CURVED TRAJECTORY
C       USE SIN(X)=X-X**3/6 AND RATIO OF BEND ANGLES 1:2:1
         DLL(1)=THETA**2/24.
         DLL(2)=DLL(1)
         DLL(3)=DLL(1)/4.
C       CORRECTION FOR MOVEMENT OF AVB3 ALONG Z AXIS
C       PIVOT TO CENTER DY=18.7 IN,DZ=26 IN AND ALF3=.75*THETA
        DL3=THETA*(14.01+7.3*THETA)
        L(3)=L(3)-DL3
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      DO 110 I=1,3
  110 BL(I)=AL(I)*(1.+DLL(I))
C     NO STEERING CONDITION AT TARGET  FRACTIONAL CURRENT DII
C    BYPASSING AVB2+3, IF NEGATIVE BYPASSING AVB1
C      IF THERE IS NO SHUNT SET DII=0.
      DII=(BL(2)*L(2)+BL(3)*L(3)-BL(1)*L(1))/(BL(2)*L(2)+BL(3)*L(3))
      DII= 0.
C     REQUIRED FIELD IN REFERENCE MAGNET
      BREF=SIBDL/(-BL(1)+(1.-DII)*(BL(2)+BL(3)))
C     ACTUAL  BEND ANGLES BL AND TAN OF BEAMANGLE AFTER MAGNETS
      TH=BREF*THETA/SIBDL
      BL(1)=BL(1)*TH
      BL(2)=BL(2)*TH*(1.-DII)
      BL(3)=BL(3)*TH*(1.-DII)
      T1=SIN(BL(1))/COS(BL(1))
      T12=SIN(BL(1)-BL(2))/COS(BL(1)-BL(2))
      T123=SIN(BL(1)-BL(2)-BL(3))/COS(BL(1)-BL(2)-BL(3))
C    ZERO IS VERT MISSTEERING AT TARGET
      ZERO=T1*(L(1)-L(2))+T12*(L(2)-L(3))+T123*L(3)
      ZERO=ZERO*1000.
      ALF3=THETA-BL(3)/2.
      THHOD=THETA-BL(3)
C    HEIGHTS TO WHICH TO SET MAGNETS AND HODO
      HAVB2=T1*(L(1)-L(2)-AL(2)/2.)+AL(2)*BL(2)/16.
      HAVB3=T1*(L(1)-L(2))+T12*(L(2)-L(3)-AL(3)/2.)
      HAVB3=HAVB3+BL(3)*AL(3)/16.
      HHOD=T1*(L(1)-L(2))+T12*(L(2)-L(4))
C   ROUGH VALUE OF NEEDED CURRENT
      CAVB=BREF*1000./4.12
      CAVB=CAVB*AMPF(CAVB)
      DCAVB=DII*CAVB
C      UN DO AVB3 MOVEMENT
      L(3)=L(3)+DL3
      RETURN
      END
      FUNCTION AMPF(D)
C     SATURATION CURVE FOR A B2 MAGNET
      A=D/1000.
      IF (A.LE.2.)  AMPF=1.
      IF (A.GT.2.)  AMPF=1.+1.2E-4*A**3*(A-2.)
      RETURN
      END
```

TABLE 1

	AVB1	AVB2	AVB3	3'Ref Mag.
Serial #	B2-10-3	2115	B2-10-2	B2-1X
Length of Steel	120.00"	238.94"	119.875"	3'
Power end	up stream	up stream	up stream	-
Z of center +	1410.974'	1443.849'	1462.578'	-
X of center +	71.871'	71.675'	71.564'	-
Magnetic Mirror *	none	downstream	up & down stream	none
$\bar{B}$ average/Bref	1.00057	.99905	1.00027	1
Δl power end	+.15"	.06"	-.22"	-
Δl no power end	+.25"	-.24"	-.28(+.21")**	-
l mag. = ∫Bdl/B average	120.40"±.10"	238.75"±.10"	119.38"±.10"	
l mag. eff = ∫Bdl/Bref	120.47"	238.53"	119.42"	

** with the mirror plate taken off

* steel plates 1.5"x30"x30"

\+ in Meson Lab coordinate system

TABLE 2.1 DII ≠ 0

50.0 GEV/C

THETA MR	B/TH G/MR	I/TH A/MR	DI/I %	H2/TH MIL/MR	H3/TH MIL/MR	HHD/TH MIL/MR	AL3/TH	AHD/TH	DYTGT MIL
-24.0	275.29	66.82	-0.152	154.08	121.18	126.54	0.7489	0.4979	0.3
-20.0	275.26	66.81	-0.160	154.06	121.12	126.51	0.7490	0.4979	0.2
-16.0	275.23	66.80	-0.167	154.05	121.06	126.49	0.7490	0.4979	0.1
-12.0	275.20	66.80	-0.175	154.03	121.01	126.46	0.7490	0.4979	0.0
-8.0	275.17	66.79	-0.183	154.01	120.95	126.43	0.7490	0.4980	0.0
-4.0	275.13	66.78	-0.191	153.99	120.90	126.40	0.7490	0.4980	0.0
4.0	275.07	66.76	-0.207	153.96	120.79	126.35	0.7490	0.4980	-0.0
8.0	275.04	66.76	-0.215	153.94	120.73	126.32	0.7490	0.4980	-0.0
12.0	275.00	66.75	-0.223	153.93	120.68	126.30	0.7490	0.4981	-0.0
16.0	274.97	66.74	-0.231	153.91	120.62	126.27	0.7490	0.4981	-0.1
20.0	274.93	66.73	-0.239	153.89	120.57	126.25	0.7491	0.4981	-0.2
24.0	274.90	66.72	-0.247	153.88	120.52	126.22	0.7491	0.4981	-0.3
28.0	274.86	66.71	-0.255	153.86	120.46	126.20	0.7491	0.4981	-0.5
32.0	274.83	66.72	-0.263	153.85	120.41	126.17	0.7491	0.4982	-0.7
36.0	274.79	66.74	-0.272	153.84	120.35	126.15	0.7491	0.4982	-1.0
40.0	274.76	66.79	-0.280	153.82	120.30	126.12	0.7491	0.4982	-1.4
44.0	274.72	66.87	-0.288	153.81	120.25	126.10	0.7491	0.4982	-1.8
48.0	274.68	66.98	-0.297	153.80	120.19	126.08	0.7491	0.4983	-2.4
52.0	274.64	67.15	-0.305	153.78	120.14	126.05	0.7491	0.4983	-3.0
56.0	274.61	67.37	-0.314	153.77	120.08	126.03	0.7492	0.4983	-3.7
60.0	274.57	67.66	-0.322	153.76	120.03	126.01	0.7492	0.4983	-4.6
64.0	274.53	68.04	-0.331	153.75	119.98	125.99	0.7492	0.4984	-5.6

TABLE 2.2 DII ≠ 0

100.0 GEV/C

THETA MR	B/TH G/MR	I/TH A/MR	DI/I %	H2/TH MIL/MR	H3/TH MIL/MR	HHD/TH MIL/MR	AL3/TH	AHD/TH	DYTGT MIL
-24.0	550.58	133.64	-0.152	154.08	121.18	126.54	0.7489	0.4979	0.3
-20.0	550.52	133.62	-0.160	154.06	121.12	126.51	0.7490	0.4979	0.2
-16.0	550.46	133.61	-0.167	154.05	121.06	126.49	0.7490	0.4979	0.1
-12.0	550.40	133.59	-0.175	154.03	121.01	126.46	0.7490	0.4979	0.0
-8.0	550.33	133.58	-0.183	154.01	120.95	126.43	0.7490	0.4980	0.0
-4.0	550.27	133.56	-0.191	153.99	120.90	126.40	0.7490	0.4980	0.0
4.0	550.14	133.53	-0.207	153.96	120.79	126.35	0.7490	0.4980	-0.0
8.0	550.07	133.51	-0.215	153.94	120.73	126.32	0.7490	0.4980	-0.0
12.0	550.01	133.50	-0.223	153.93	120.68	126.30	0.7490	0.4981	-0.0
16.0	549.94	133.50	-0.231	153.91	120.62	126.27	0.7490	0.4981	-0.1
20.0	549.87	133.67	-0.239	153.89	120.57	126.25	0.7491	0.4981	-0.2
24.0	549.80	134.08	-0.247	153.88	120.52	126.22	0.7491	0.4981	-0.3
28.0	549.73	134.88	-0.255	153.86	120.46	126.20	0.7491	0.4981	-0.5
32.0	549.66	136.24	-0.263	153.85	120.41	126.17	0.7491	0.4982	-0.7

TABLE 2.3 DII ≠ 0

150.0 GEV/C

THETA MR	B/TH G/MR	I/TH A/MR	DI/I %	H2/TH MIL/MR	H3/TH MIL/MR	HHD/TH MIL/MR	AL3/TH	AHD/TH	DYTGT MIL
-20.0	825.78	200.43	-0.160	154.06	121.12	126.51	0.7490	0.4979	0.2
-16.0	825.69	200.41	-0.167	154.05	121.06	126.49	0.7490	0.4979	0.1
-12.0	825.60	200.39	-0.175	154.03	121.01	126.46	0.7490	0.4979	0.0
-8.0	825.50	200.36	-0.183	154.01	120.95	126.43	0.7490	0.4980	0.0
-4.0	825.40	200.34	-0.191	153.99	120.90	126.40	0.7490	0.4980	0.0
4.0	825.21	200.29	-0.207	153.96	120.79	126.35	0.7490	0.4980	-0.0
8.0	825.11	200.27	-0.215	153.94	120.73	126.32	0.7490	0.4980	-0.0
12.0	825.01	200.38	-0.223	153.93	120.68	126.30	0.7490	0.4981	-0.0
16.0	824.91	201.17	-0.231	153.91	120.62	126.27	0.7490	0.4981	-0.1
20.0	824.80	203.28	-0.239	153.89	120.57	126.25	0.7491	0.4981	-0.2

TABLE 2.4 DII ≠ 0

200.0 GEV/C

THETA MR	B/TH G/MR	I/TH A/MR	DI/I %	H2/TH MIL/MR	H3/TH MIL/MR	HHD/TH MIL/MR	AL3/TH	AHD/TH	DYTGT MIL
-16.0	1100.92	267.21	-0.167	154.05	121.06	126.49	0.7490	0.4979	0.1
-12.0	1100.79	267.18	-0.175	154.03	121.01	126.46	0.7490	0.4979	0.0
-8.0	1100.67	267.15	-0.183	154.01	120.95	126.43	0.7490	0.4980	0.0
-4.0	1100.54	267.12	-0.191	153.99	120.90	126.40	0.7490	0.4980	0.0
4.0	1100.28	267.06	-0.207	153.96	120.79	126.35	0.7490	0.4980	-0.0
8.0	1100.14	267.07	-0.215	153.94	120.73	126.32	0.7490	0.4980	-0.0
12.0	1100.01	268.26	-0.223	153.93	120.68	126.30	0.7490	0.4981	-0.0
16.0	1099.87	272.63	-0.231	153.91	120.62	126.27	0.7490	0.4981	-0.1

50.0 GEV/C

TABLE 3.1 DII = 0

THETA MR	B/TH G/MR	I/TH A/MR	DI/I %	H2/TH MIL/MR	H3/TH MIL/MR	HHD/TH MIL/MR	AL3/TH	AHD/TH	DYTGT MIL
-24.0	275.92	66.97	0.000	154.41	121.70	127.06	0.7488	0.4975	-12.8
-20.0	275.92	66.97	0.000	154.41	121.67	127.05	0.7487	0.4975	-11.3
-16.0	275.92	66.97	0.000	154.41	121.64	127.05	0.7487	0.4975	-9.5
-12.0	275.92	66.97	0.000	154.41	121.61	127.05	0.7487	0.4975	-7.5
-8.0	275.93	66.97	0.000	154.41	121.58	127.05	0.7487	0.4975	-5.2
-4.0	275.93	66.97	0.000	154.41	121.56	127.05	0.7487	0.4975	-2.7
4.0	275.93	66.97	0.000	154.41	121.50	127.05	0.7487	0.4975	3.0
8.0	275.93	66.97	0.000	154.41	121.47	127.05	0.7487	0.4975	6.1
12.0	275.92	66.97	0.000	154.41	121.45	127.05	0.7487	0.4975	9.5
16.0	275.92	66.97	0.000	154.41	121.42	127.05	0.7487	0.4975	13.1
20.0	275.92	66.97	0.000	154.41	121.39	127.05	0.7487	0.4975	16.9
24.0	275.92	66.97	0.000	154.41	121.37	127.06	0.7488	0.4975	20.9
28.0	275.92	66.97	0.000	154.42	121.34	127.06	0.7488	0.4975	25.0
32.0	275.92	66.98	0.000	154.42	121.31	127.06	0.7488	0.4975	29.4
36.0	275.92	67.02	0.000	154.42	121.29	127.06	0.7488	0.4975	33.9
40.0	275.91	67.07	0.000	154.43	121.26	127.07	0.7488	0.4975	38.6
44.0	275.91	67.16	0.000	154.43	121.24	127.07	0.7488	0.4975	43.5
48.0	275.91	67.29	0.000	154.44	121.21	127.08	0.7488	0.4975	48.5
52.0	275.91	67.47	0.000	154.44	121.19	127.08	0.7488	0.4975	53.7
56.0	275.90	67.71	0.000	154.45	121.16	127.09	0.7488	0.4975	59.0
60.0	275.90	68.02	0.000	154.46	121.14	127.10	0.7488	0.4975	64.5
64.0	275.90	68.41	0.000	154.46	121.12	127.10	0.7488	0.4975	70.1

TABLE 3.2 DII=0

100.0 GEV/C

THETA MR	B/TH G/MR	I/TH A/MR	DI/I %	H2/TH MIL/MR	H3/TH MIL/MR	HHD/TH MIL/MR	AL3/TH	AHD/TH	DYTGT MIL
-24.0	551.84	133.94	0.000	154.41	121.70	127.06	0.7488	0.4975	-12.8
-20.0	551.85	133.94	0.000	154.41	121.67	127.05	0.7487	0.4975	-11.3
-16.0	551.85	133.94	0.000	154.41	121.64	127.05	0.7487	0.4975	-9.5
-12.0	551.85	133.94	0.000	154.41	121.61	127.05	0.7487	0.4975	-7.5
-8.0	551.85	133.94	0.000	154.41	121.58	127.05	0.7487	0.4975	-5.2
-4.0	551.85	133.94	0.000	154.41	121.56	127.05	0.7487	0.4975	-2.7
4.0	551.85	133.94	0.000	154.41	121.50	127.05	0.7487	0.4975	3.0
8.0	551.85	133.94	0.000	154.41	121.47	127.05	0.7487	0.4975	6.1
12.0	551.85	133.94	0.000	154.41	121.45	127.05	0.7487	0.4975	9.5
16.0	551.85	133.97	0.000	154.41	121.42	127.05	0.7487	0.4975	13.1
20.0	551.85	134.15	0.000	154.41	121.39	127.05	0.7487	0.4975	16.9
24.0	551.84	134.59	0.000	154.41	121.37	127.06	0.7488	0.4975	20.9
28.0	551.84	135.43	0.000	154.42	121.34	127.06	0.7488	0.4975	25.0
32.0	551.84	136.83	0.000	154.42	121.31	127.06	0.7488	0.4975	29.4

TABLE 3.3 DII=0

150.0 GEV/C

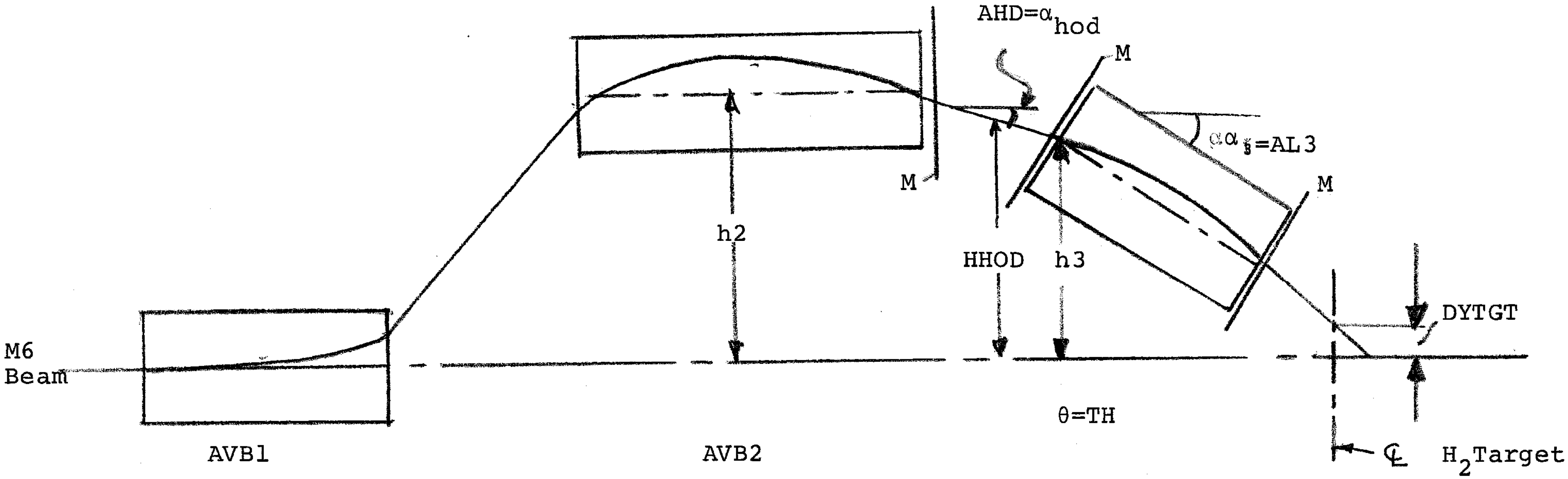
THETA MR	B/TH G/MR	I/TH A/MR	DI/I %	H2/TH MIL/MR	H3/TH MIL/MR	HHD/TH MIL/MR	AL3/TH	AHD/TH	DYTGT MIL
-20.0	827.77	200.91	0.000	154.41	121.67	127.05	0.7487	0.4975	-11.3
-16.0	827.77	200.92	0.000	154.41	121.64	127.05	0.7487	0.4975	-9.5
-12.0	827.77	200.92	0.000	154.41	121.61	127.05	0.7487	0.4975	-7.5
-8.0	827.78	200.92	0.000	154.41	121.58	127.05	0.7487	0.4975	-5.2
-4.0	827.78	200.92	0.000	154.41	121.56	127.05	0.7487	0.4975	-2.7
4.0	827.78	200.92	0.000	154.41	121.50	127.05	0.7487	0.4975	3.0
8.0	827.78	200.92	0.000	154.41	121.47	127.05	0.7487	0.4975	6.1
12.0	827.77	201.05	0.000	154.41	121.45	127.05	0.7487	0.4975	9.5
16.0	827.77	201.89	0.000	154.41	121.42	127.05	0.7487	0.4975	13.1
20.0	827.77	204.07	0.000	154.41	121.39	127.05	0.7487	0.4975	16.9

TABLE 3.4 DII=0

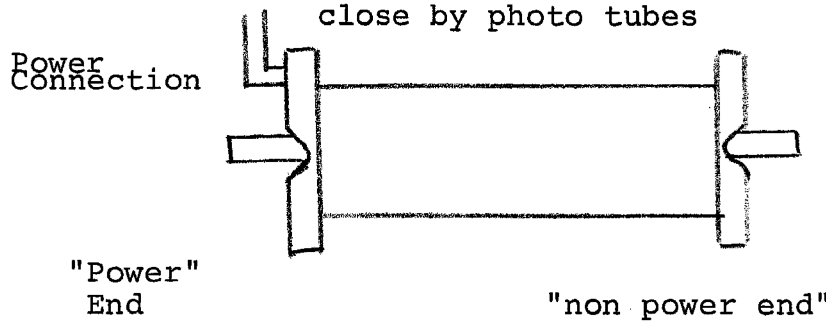
200.0 GEV/C

THETA MR	B/TH G/MR	I/TH A/MR	DI/I %	H2/TH MIL/MR	H3/TH MIL/MR	HHD/TH MIL/MR	AL3/TH	AHD/TH	DYTGT MIL
-16.0	1103.70	267.89	0.000	154.41	121.64	127.05	0.7487	0.4975	-9.5
-12.0	1103.70	267.89	0.000	154.41	121.61	127.05	0.7487	0.4975	-7.5
-8.0	1103.70	267.89	0.000	154.41	121.58	127.05	0.7487	0.4975	-5.2
-4.0	1103.70	267.89	0.000	154.41	121.56	127.05	0.7487	0.4975	-2.7
4.0	1103.70	267.89	0.000	154.41	121.50	127.05	0.7487	0.4975	3.0
8.0	1103.70	267.93	0.000	154.41	121.47	127.05	0.7487	0.4975	6.1
12.0	1103.70	269.19	0.000	154.41	121.45	127.05	0.7487	0.4975	9.5
16.0	1103.70	273.67	0.000	154.41	121.42	127.05	0.7487	0.4975	13.1

Figure 1



θ = scattering angle
M = mirror plate to shield close by photo tubes



α_3 = tilt of AVB3

α_{hod} = tilt of beam in hodoscope between AVB2 and AVB3

h_3 = excursion of AVB3 at upstream edge of steel

M = magnetic mirror plate 1.5"x30"x30"

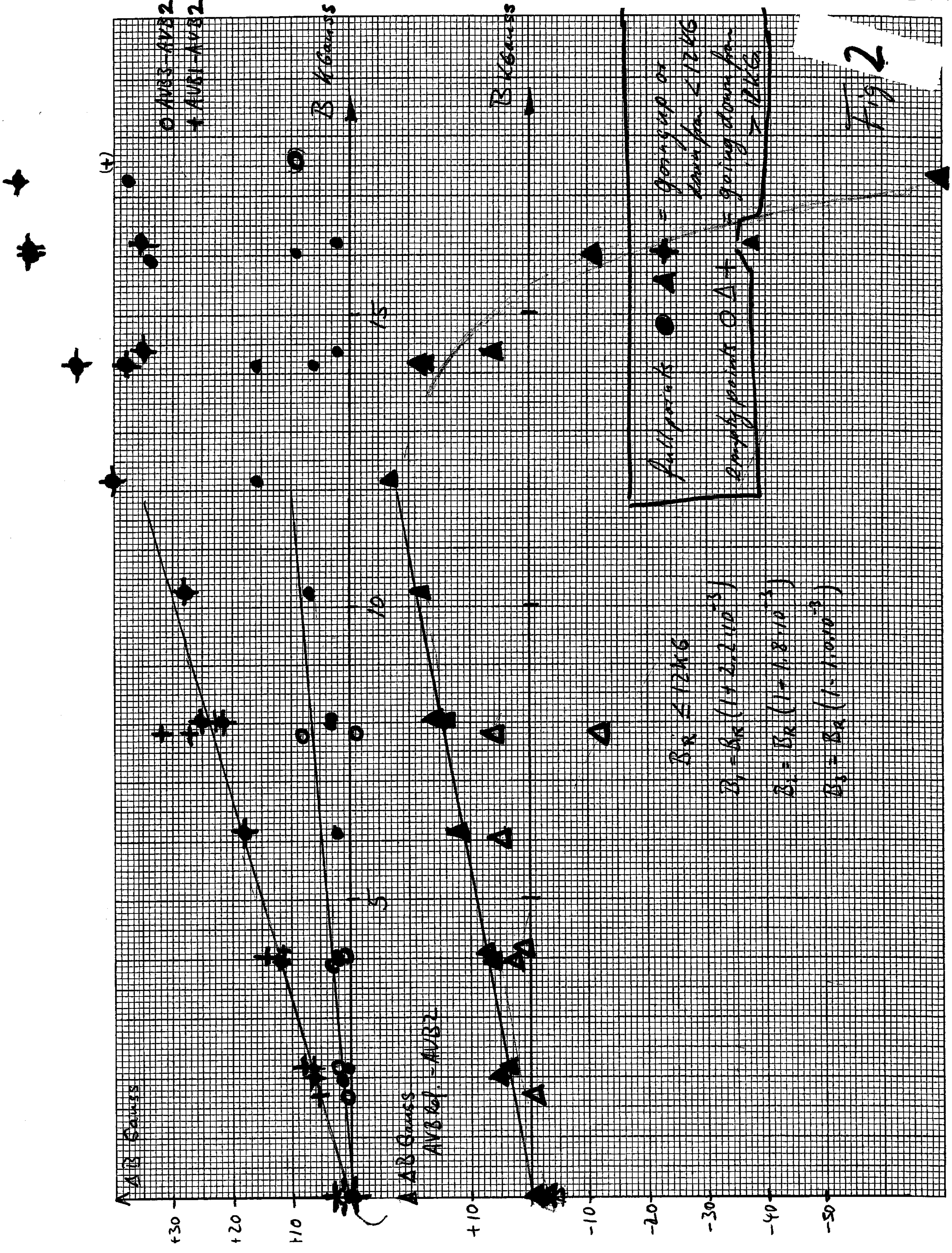

ΔB Gauss
+30
+20
+10
5
10
15
B kGauss
○ AVB3-AVB2
+ AVB1-AVB2
(+)
ΔB Gauss
AVB Ref. -AVB2
+10
-10
-20
-30
-40
-50
B kGauss
$B_R \le 12kG$
$B_1 = B_R(1 + 2.2 \cdot 10^{-3})$
$B_2 = B_R(1 + 1.8 \cdot 10^{-3})$
$B_3 = B_R(1 - 1.0 \cdot 10^{-3})$
full points ● ▲ + = going up or down from < 12kG
empty points ○ Δ + = going down from > 12kG

Fig 2

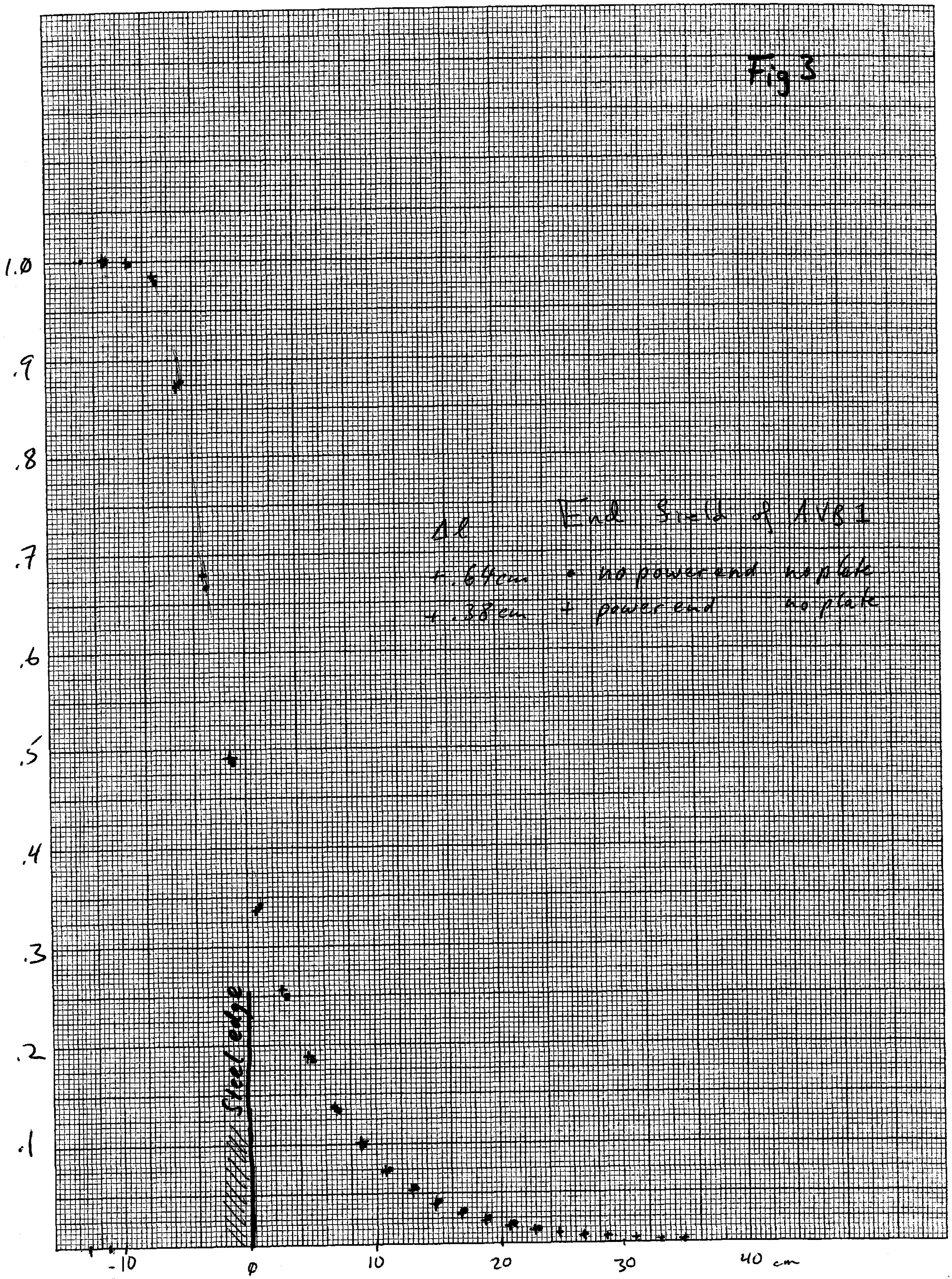


Fig 3
End field of 1VB1
Δl
+ .64cm • no power end no plate
+ .38cm + power end no plate
Steel edge
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
-10
0
10
20
30
40 cm

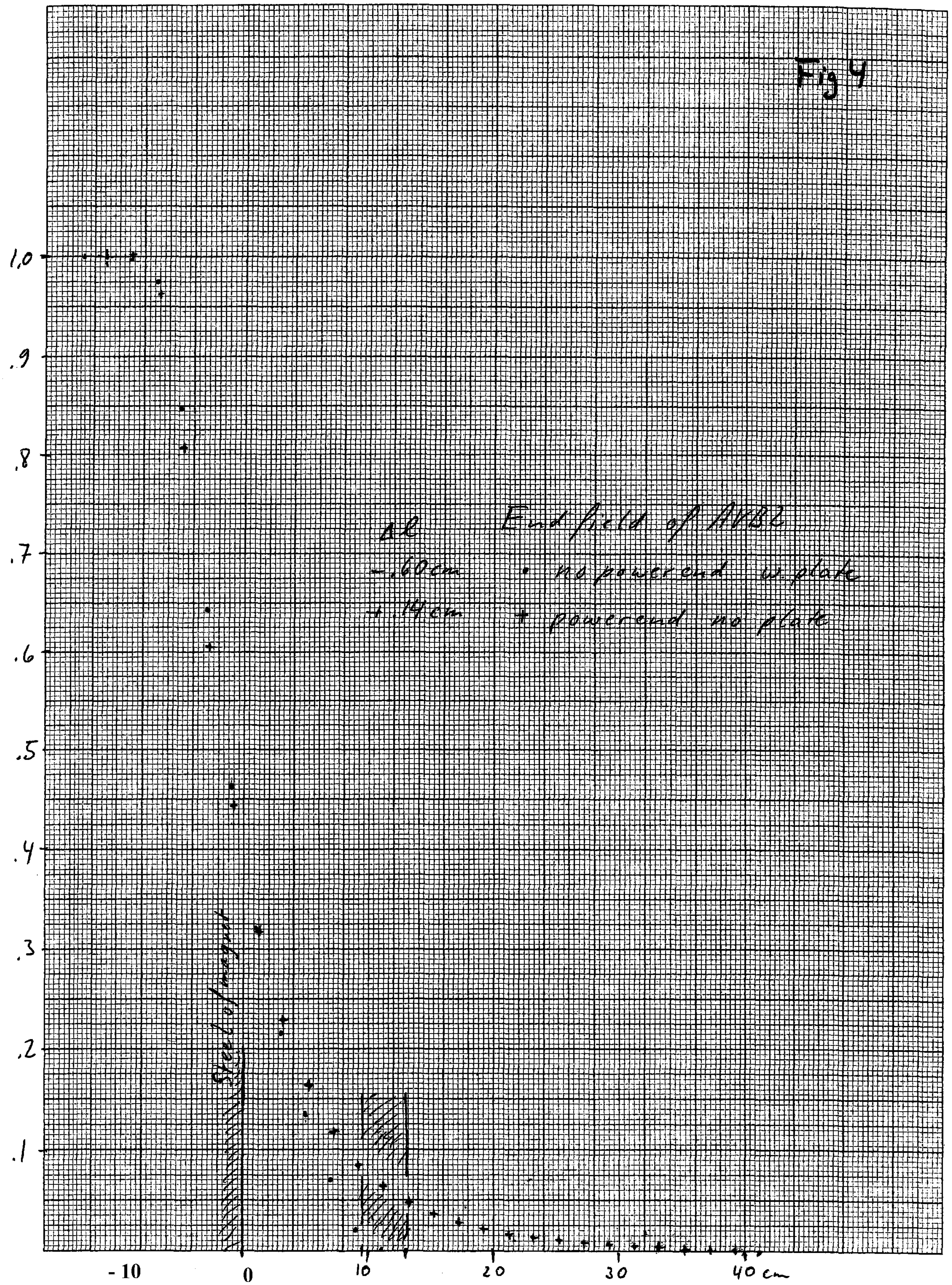


Fig 4
ΔL
End field of AVB2
-.60cm
• no powerend w. plate
+.14cm
+ powerend no plate
Steel of magnet
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
-10
0
10
20
30
40 cm

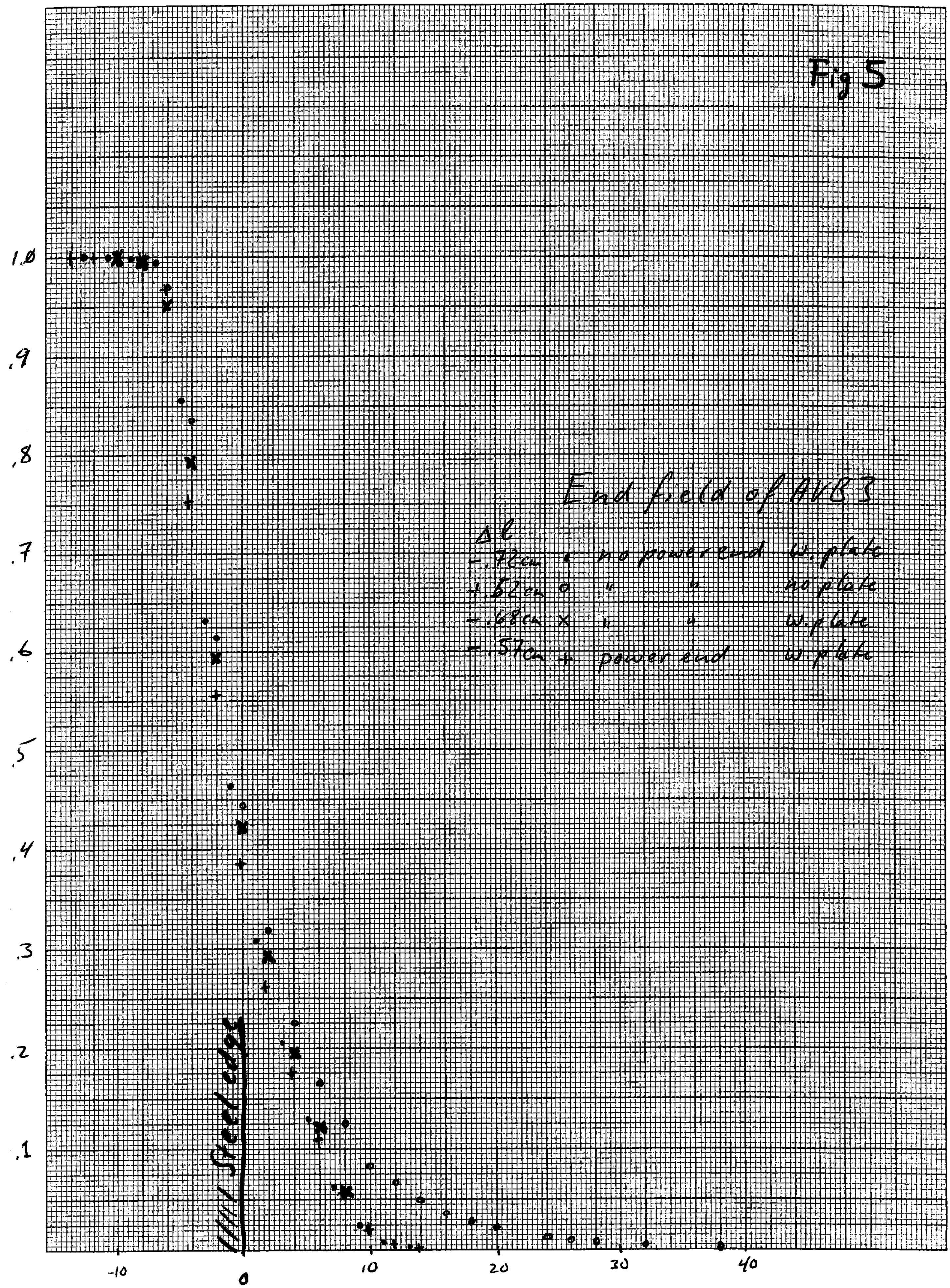


Fig 5
End field of AVB3
Δl
-.72cm • no power end w. plate
+.62cm o " " no plate
-.68cm x " " w. plate
-.57cm + power end w. plate
Steel edge
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
-10
0
10
20
30
40

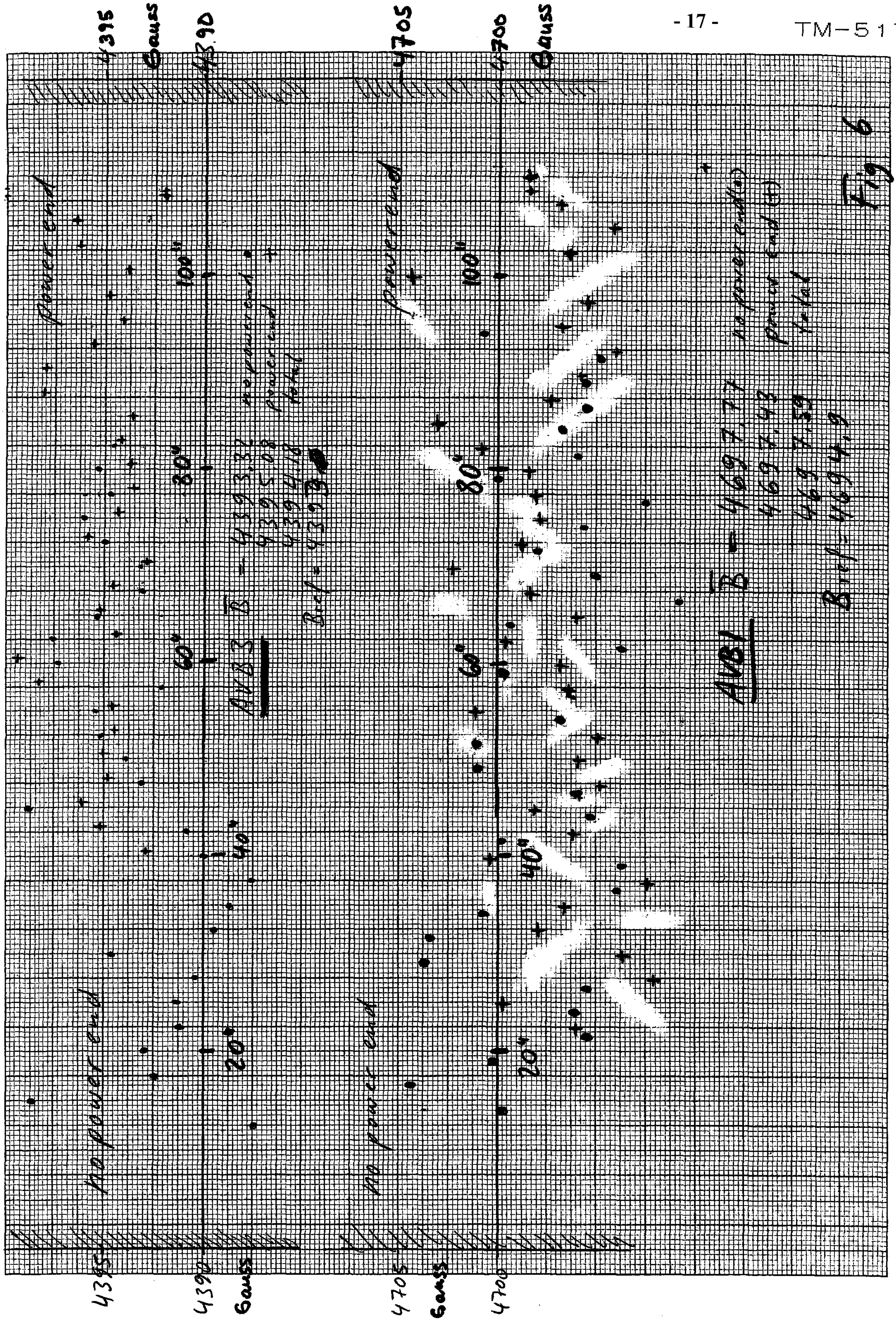
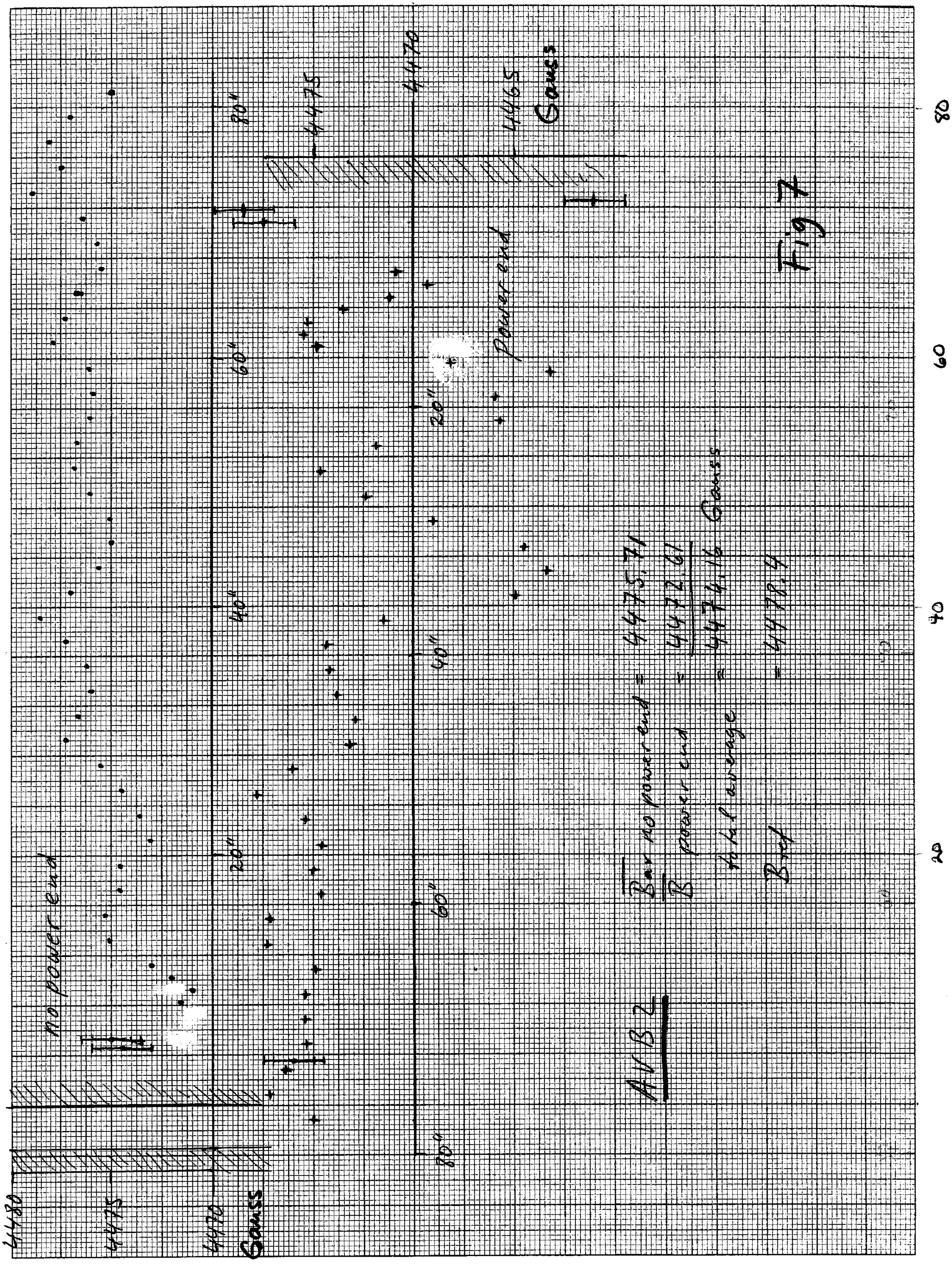
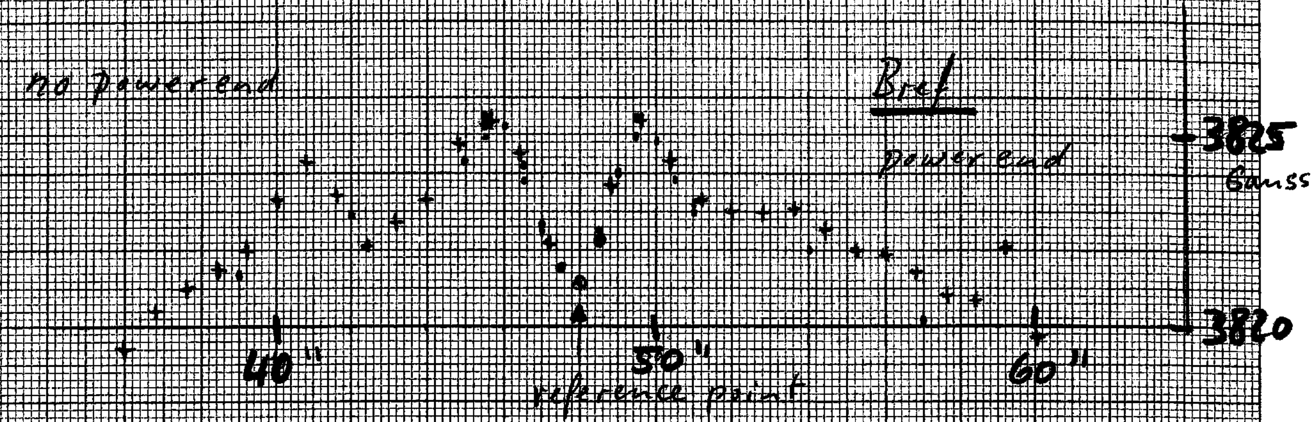

4395
4390
Gauss
4705
4700
Gauss
no power end
power end
20"
40"
60"
80"
100"
AVB3 B̄ = 4393.32 no power end •
4395.08 power end +
4394.18 total
Bref = 4393.3
AVB1 B̄ = 4697.77 no power end (•)
4697.42 power end (+)
4697.59 total
Bref = 4694.9

Fig 6


AVB2
$\overline{B}_{av}$ no power end = 4475.71
$\overline{B}$ power end = 4472.61
total average = 4474.16 Gauss
B_{ref} = 4478.4
no power end
Power end
Gauss
Fig 7



no powerend
Bref
powerend
3825
Gauss
3820
40"
50"
60"
reference point

Fig 8